Preliminary results from the Community Earth System Model for the GASS/RGCM/ASR CAUSES project

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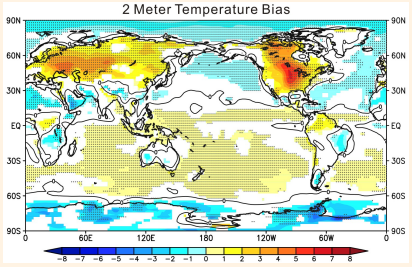
Motivation:

The surface warm biases over mid-latitude continents during the summer time is a long-standing issue for many climate models (Ma et al. 2014). Such warm biases can happen in a few days of model integrations (stippling indicates regions where this occurs). The warm biases involve interactions of precipitation, clouds, and radiation processes on the surface energy budget, which determines the temperature simulations near the surface. The issue is important because such biases can affect the projections of future temperature change over land.



CAUSES project:

The Clouds Above the United States and Errors at the Surface (CAUSES) is a joint GASS/RGCM/ASR intercomparison project aiming to evaluate clouds, radiation, and precipitation in hindcast mode and compare to ground-based and other observations. (http://portal.nersc.gov/project/capt/CAUSES/)

Project foci:

1. On the errors in clouds and radiation (led by Cyril Morcrette, Kwinten Van Weverberg and Jon Petch of Met Office)
2. On the simulated precipitation and surface energy budget (led by Hsi-Yen Ma, Steve Klein, Shaocheng Xie of LLNL)

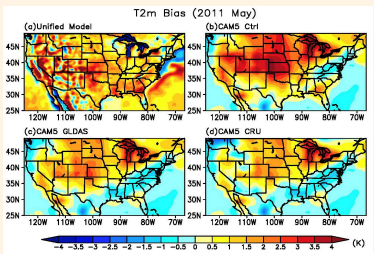
The science questions for LLNL team are:

- What is the relative contribution of precipitation errors to the temperature errors?
- Which type of precipitating convection systems dominate the errors in the surface precipitation?
- Does this atmosphere provide the correct amount of precipitation for the soil?
- Does the surface energy balance reveal signs that evaporation is underestimated due to the lack of soil moisture?

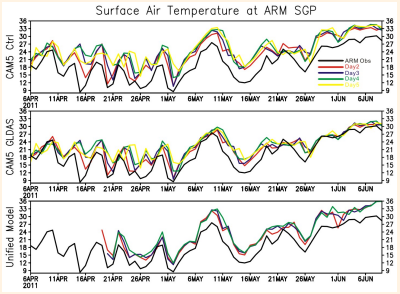
Models and experiments

- Models: (1) Met Office GA6.0 (N512); (2) CAM5.1 FV (0.9x1.25L30) with 3 different land initial conditions (Ctrl: Nudging method from Boyle et al. 2005; Two offline CLM runs with GLDAS and CRU forcing data)
- Experiments: 5-day long short-term hindcasts for April-August of 2008, 2011 starting everyday at 00Z.

T_{2m} biases (Day 2 hindcasts)

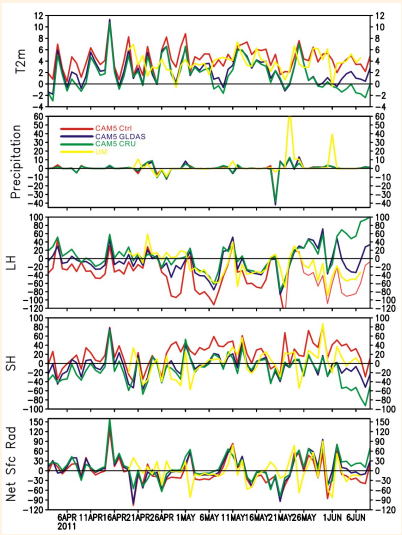


T_{2m} biases examined by ARM observations at SGP



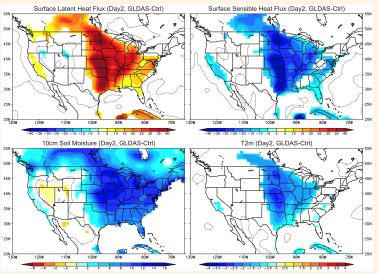
Both Unified Model and CAM5 show warm biases over the central US in just a few days. Smaller T_{2m} biases are found in the CAM5-GLDAS hindcasts.

Surface fluxes examined with ARM observations at SGP (Day 2)



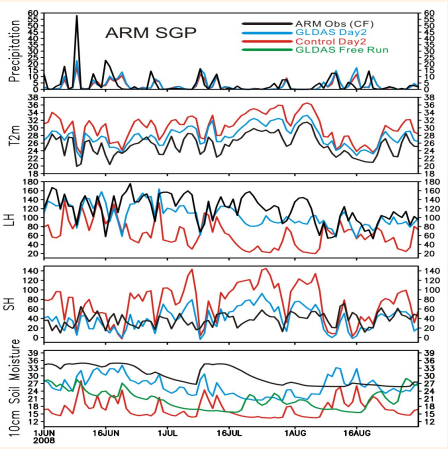
Day 2 hindcasts from both models tend to produce lower latent heat (LH) and higher sensible heat (SH) fluxes compared to ARM obs.

Surface fluxes v.s. T_{2m} from CAM5

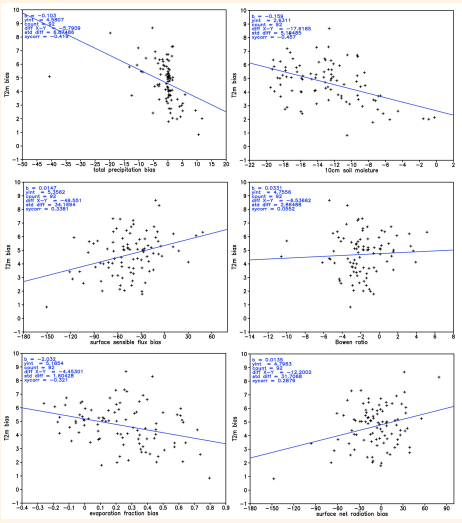


Higher 10cm soil moisture in the GLDAS hindcasts produce higher surface latent heat flux, and lower sensible heat flux and surface air temperature.

Surface Fluxes examined with ARM observations at SGP (CAM5, Day 2)



Initial 10cm soil moisture can affect simulated surface latent and sensible heat fluxes, which can affect T_{2m} significantly.



Precipitation and 10cm soil moisture show larger correlations with T_{2m} bias at ARM SGP site.

Summary and Future Work

- Our preliminary results suggest that the low soil moisture in CLM resulting from biased low precipitation is likely the cause of surface warm temperature biases.
- Additional sensitivity experiments will be carried out to identify the bias contribution from the atmospheric component, land component or atmosphere-land interactions.
- Detailed analysis of T_{2m} biases and surface energy balance terms.

Acknowledgement:

This work is supported by the Regional and Global Climate Modeling and the Atmospheric System Research Programs for the Office of Science of the U.S Dept. of Energy. This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. LLNL-POST-651098

References: 1. Ma, H.-Y., and coauthors, 2014: On the Correspondence between mean forecast errors and climate errors in CMIP5 models. *J. Climate*, 27, 1781-1798. 2. Boyle, J. S., and coauthors, 2005: Diagnosis of Community Atmospheric Model 2 (CAM2) in numerical weather forecast configuration at Atmospheric Radiation Measurement sites. *J. Geophys. Res.*, 110, D15S15, doi:10.1029/2004JD005042.